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REPORT 974-012-1

DESIGNING AND TESTING
INTERTANK AIR BEARINGS

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RM-141-65

June 1965

[redacted]

FOREWORD

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[redacted] submits this report in compliance with Item 4.2 of the Development Objectives of Contract 974.

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Research Manager

ABSTRACT

The two objectives of this task were to study the possibility of designing an improved plenum-type air bearing that is particularly suitable for a cleanroom environment and (making a radical departure from this type of bearing) to design one that incorporates its own blower fan.

CONTENTS

SECTION		PAGE
1	INTRODUCTION	1
2	TECHNICAL DISCUSSION	2
	2.1 PLENUM-TYPE BEARING	2
	2.2 SELF-POWERED AIR BEARING	4

ILLUSTRATIONS

FIGURE		PAGE
1	Plenum Type Air Bearing	3
2	Air Bearing Using Transverse-Flow Fan	5
3	Scheme of Air Bearing with Transverse-Flow Fan	7
4	Layout of Air Bearing Test Bed	8
5	Air Bearing Test Bed Showing Fan Installation	9
6	Air Bearing Test Bed Showing Fan Installed and Wheel	10

1. INTRODUCTION

The type of air bearing presently in use consists of a tube into which air is pumped and then released through slots or holes in a segment of the periphery. Adjustable flanges are provided on each side of the film to permit the release of air between the bearing and the film at a controlled rate, thereby maintaining a cushion over which the film is transported. When the flanges are adjusted to suit the specific film width, the slots or holes outside of the flanges are closed to prevent loss of air and collapse of the air cushion between.

This type of air bearing requires a high flow of air, which, in the case of the HTA-5 processor, necessitated a blower of 10 horsepower producing 1740 cfm at a static pressure of approximately 20 inches of water.

An undesirable result of the high air flow is the release of aerosol spray caused by the air impinging on the liquid present on the film. To overcome this problem, a plenum-type bearing was constructed in which the film is totally enclosed from tank to tank.

As an alternative to this type of air bearing, one in which the air pressure and flow would be generated internally was studied.

Where one main blower is supplied for all bearings in a processor, a high pressure drop must be allowed for in all main and branch feeder ducts (thus increasing the initial horsepower requirements) or as an alternative, minimizing pressure drops by providing all ducts with as large a cross sectional area as is practical. Supplying each bearing with a blower coupled directly to it only partially solves the problem of efficiency and compactness, since with the pressure and flow required, these blowers are of a significant size. High performance blowers of a smaller envelope are available but these are custom built and operate at very high speeds.

2. TECHNICAL DISCUSSION

2.1 PLENUM-TYPE BEARING

A study made of the requirements for an improved bearing showed that the following requirements should be considered:

1) Completely enclose the film in its passage between tanks.

2) Reduce the air flow required by enclosing the film in a tunnel, the entrance and exit of which would be below the liquid level in the tanks.

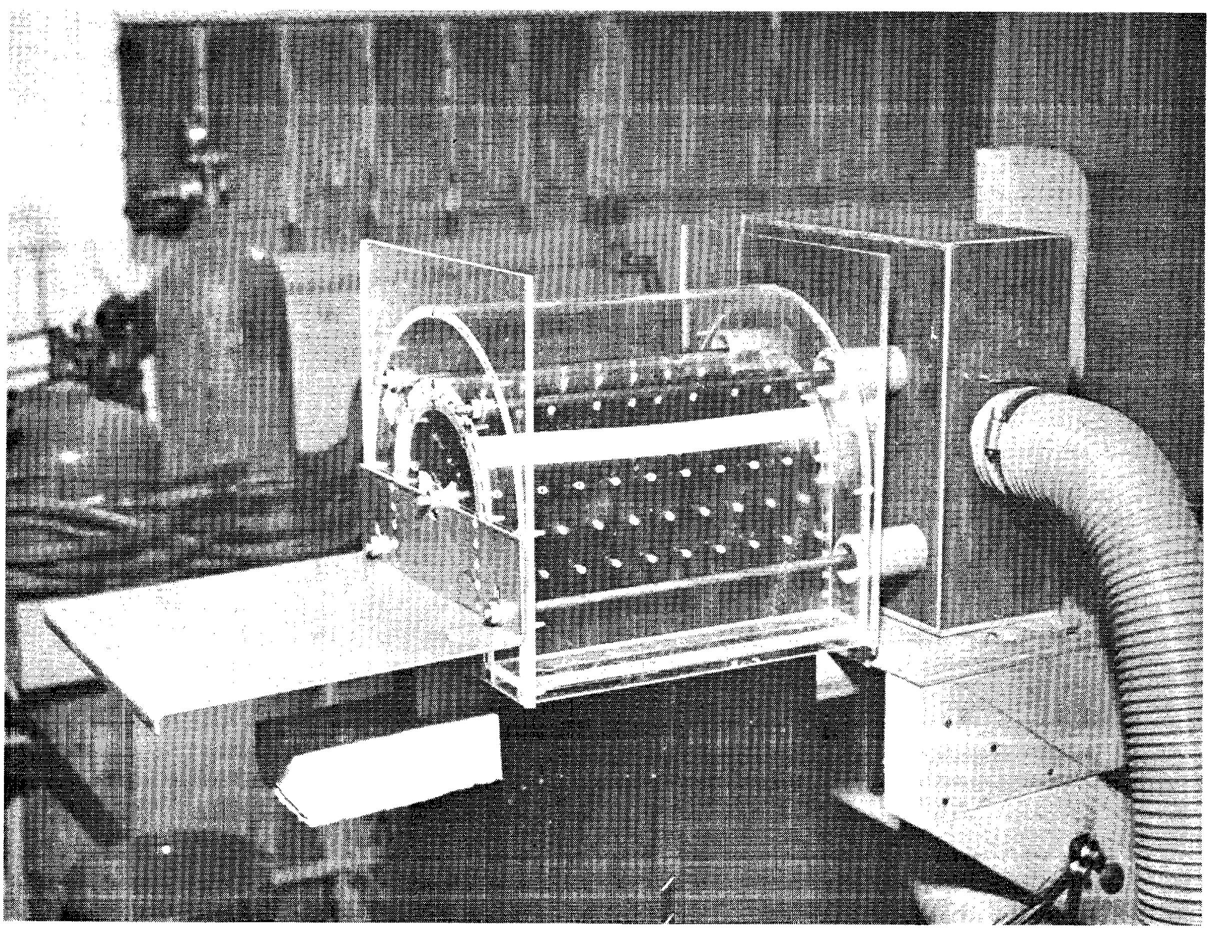
3) Provide air release holes that would center the film in the tunnel by equalizing the air pressure on both sides of the film; also, by closing the release holes to control the air pressure, possibly permitting the passage of all widths of films without the use of adjustable flanges.

4) Reduce the aerosol spray by controlling the release of air.

Figure 1 illustrates the design selected to meet the above requirements. It is, in effect, a tunnel which carries the film from one tank to another. A satisfactory air cushion was obtained with a load of 1 pound after the air flow on each side of the film had been balanced by increasing the air to the underside of the film and decreasing it against the opposite side of the film.

It was found that the film oscillated at a high frequency at the entrance and exit slots. Additional air release holes were added in the film path, which reduced the oscillations but did not eliminate them. When the air bearing was positioned over a tank of water with the film entrance and exit slots under the surface, film oscillation was damped. Because of the favorable result of this test, a method of extending the sides of the film path further into the solution will be developed and testing will be resumed.

At the time of this report, further tests are scheduled to plot air pressure and flow against the load lifting capability of the bearing.



974-012-1

Figure 1. Plenum Type Air Bearing

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2.2 SELF-POWERED AIR BEARING

As an extension of the work being carried out on the plenum-type bearing, a design study was made for a self-powered air bearing in which a fan would be incorporated to generate the air pressure and flow necessary to provide a transport cushion.

The use of a standard centrifugal blower, squirrel-cage wheel as a built-in power source presents difficulty because, to obtain optimum efficiency at the given design speed, the width of the wheel should not generally exceed 0.6 of the diameter. Various methods of avoiding this restriction can be employed, such as the use of two wheels, but achieving even flow becomes a serious problem over the length of the 9-1/2-inch bearing required. A mockup model of a bearing for a single film width of 70mm was constructed and provided a reasonable cushion after suitable flow restrictors had been provided to even the flow over the upper 180 degree half of the model. On the basis of the encouraging results obtained from the crude model an intensive study was made of all available types of blowers. (See Monthly Progress Report No. 6)

A new type of fan developed in Europe, the transverse-flow fan, showed promise for this application. A conventional centrifugal blower draws in air axially and discharges it radially. The transverse-flow fan draws air inward radially and discharges it outward radially through a different section of the fan periphery.

The advantage of incorporating this type of fan in an air bearing is that higher static pressures are obtainable for the same rotor diameter (a pressure coefficient of 1.8 to 5.5 as against 0.60 to 1.10) over a length restricted only by structural considerations, such as housing strength. A second mockup bearing, using an available wheel 1.8 inches wide, confirmed the feasibility of this concept (see Figure 2). The main problem appeared to be the air flow distribution over the required 9-1/2-inch length, which was hoped to be solved by using the transverse-flow fan.

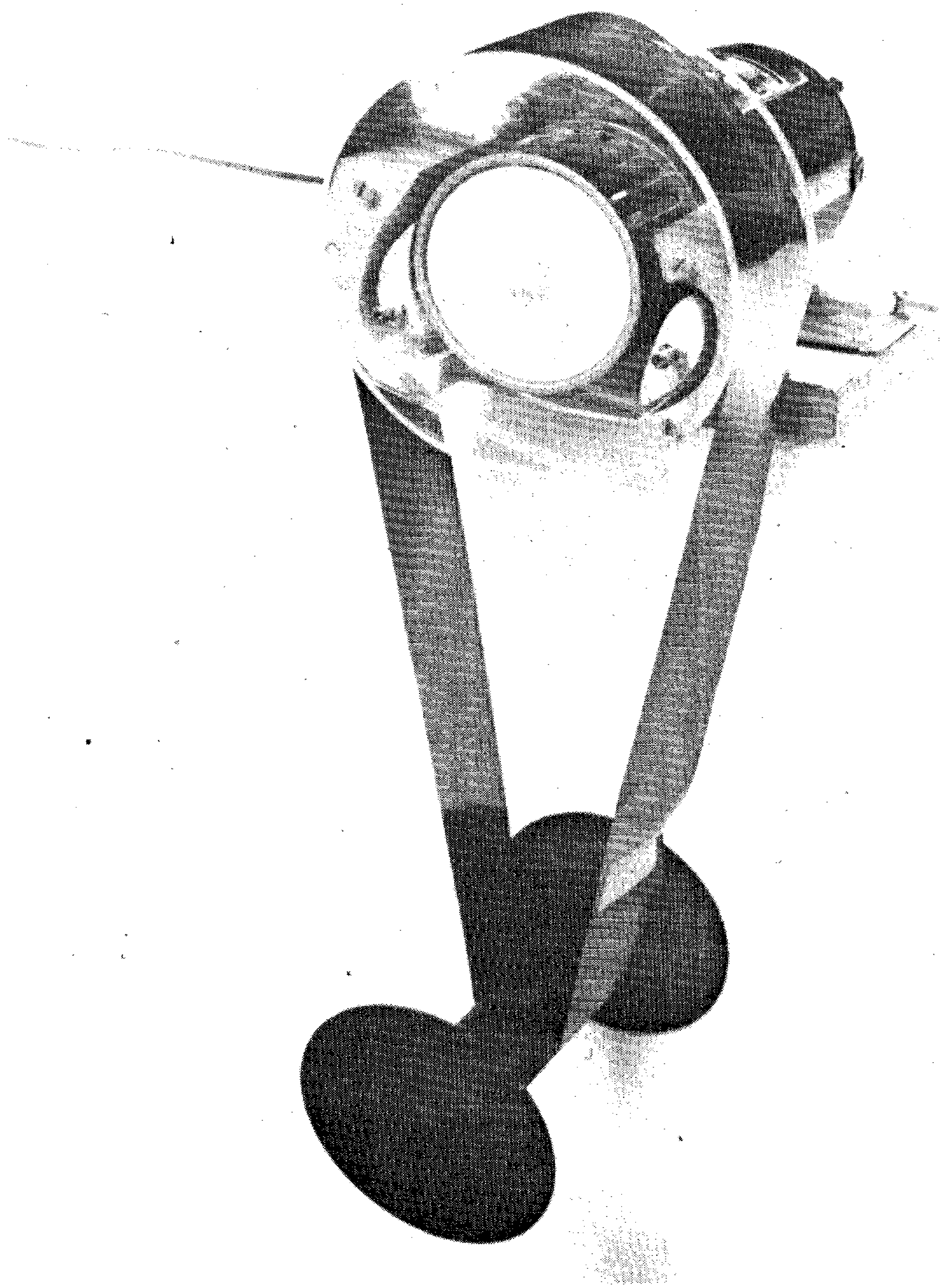

Figure 2. Air Bearing Using Transverse-Flow Fan

The transverse-flow type fan selected was the Coester type in which two vortex generators cause a flow of air radially through the fan when the wheel is rotated. This type was selected since the drawing of air in through the lower half of the bearing and expelling it through the upper half best suited an air bearing configuration. The licensee of this

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design in the U.S.A. [redacted] cooperated to develop this concept, but unfortunately problems arose in this companys' development program. It was found that a sudden transient obstruction in the output air flow could cause a reversal of flow in the vortex generators and therefore in the fan itself. In terms of an air bearing, this would cause the film to be drawn into the bearing.

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A further design concept was proposed by the [redacted] in which a Datwyler type of transverse-flow fan was integrated. However, this investigation was not pursued because of the air intake section being adjacent to one side of the film loop (see Figure 3).

As an alternative to utilizing the transverse-fan concept, an experimental test stand is now under construction (see Figure 4) to determine whether a combination of propellers and fans can be utilized. Parts required at the time of this report are all in manufacture. (See Figures 5 and 6.)

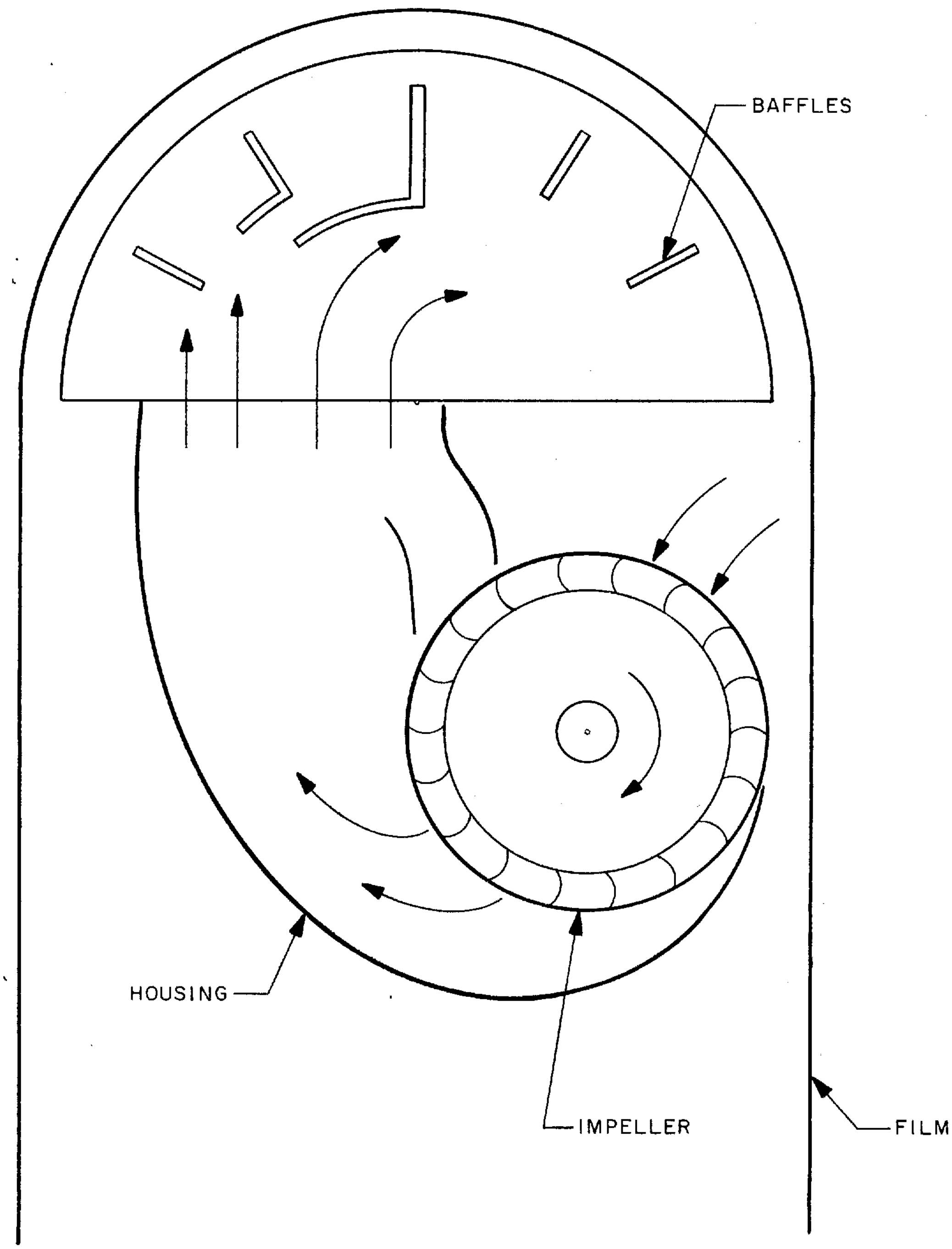

Figure 3. Scheme of Air Bearing with Transverse-Flow Fan

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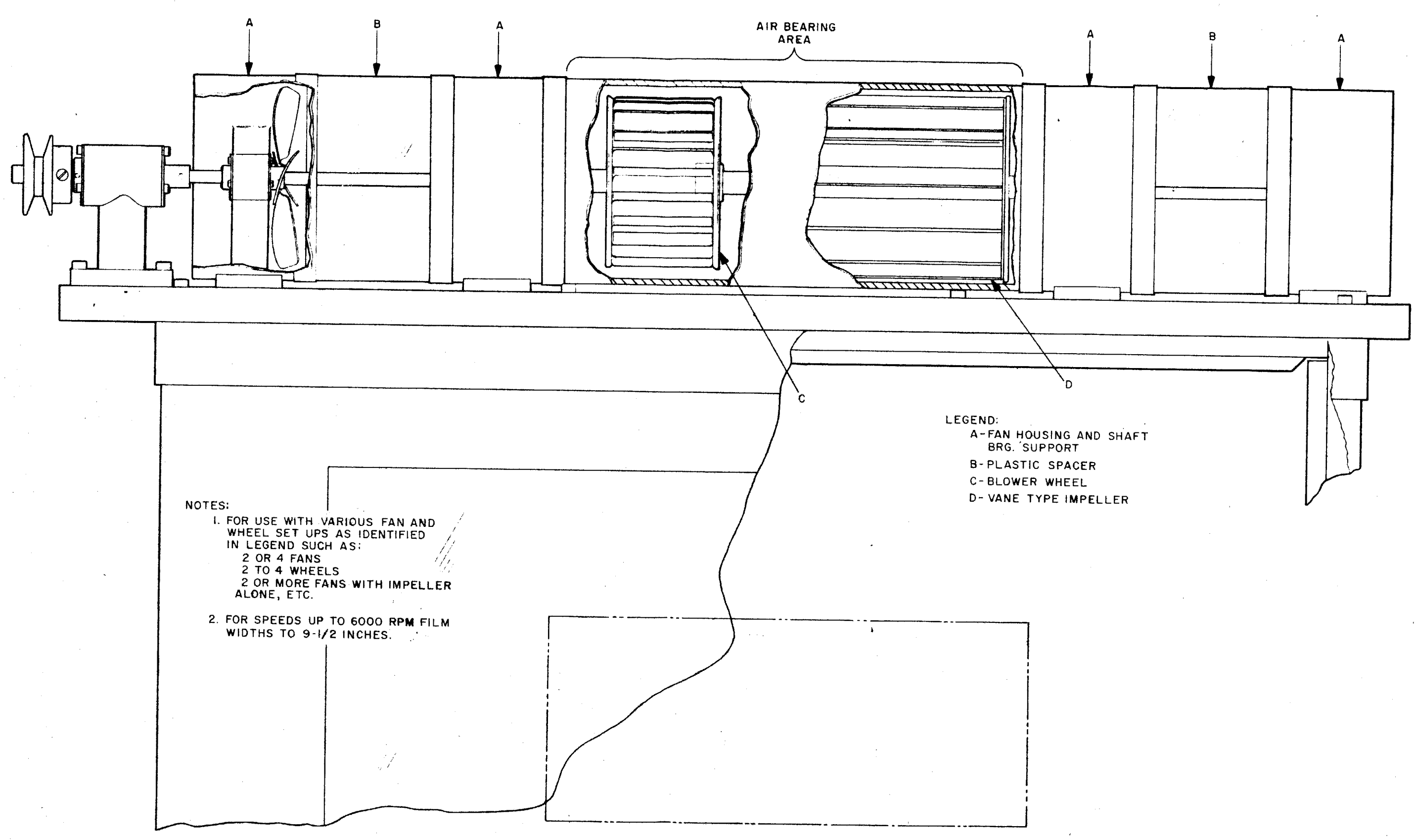
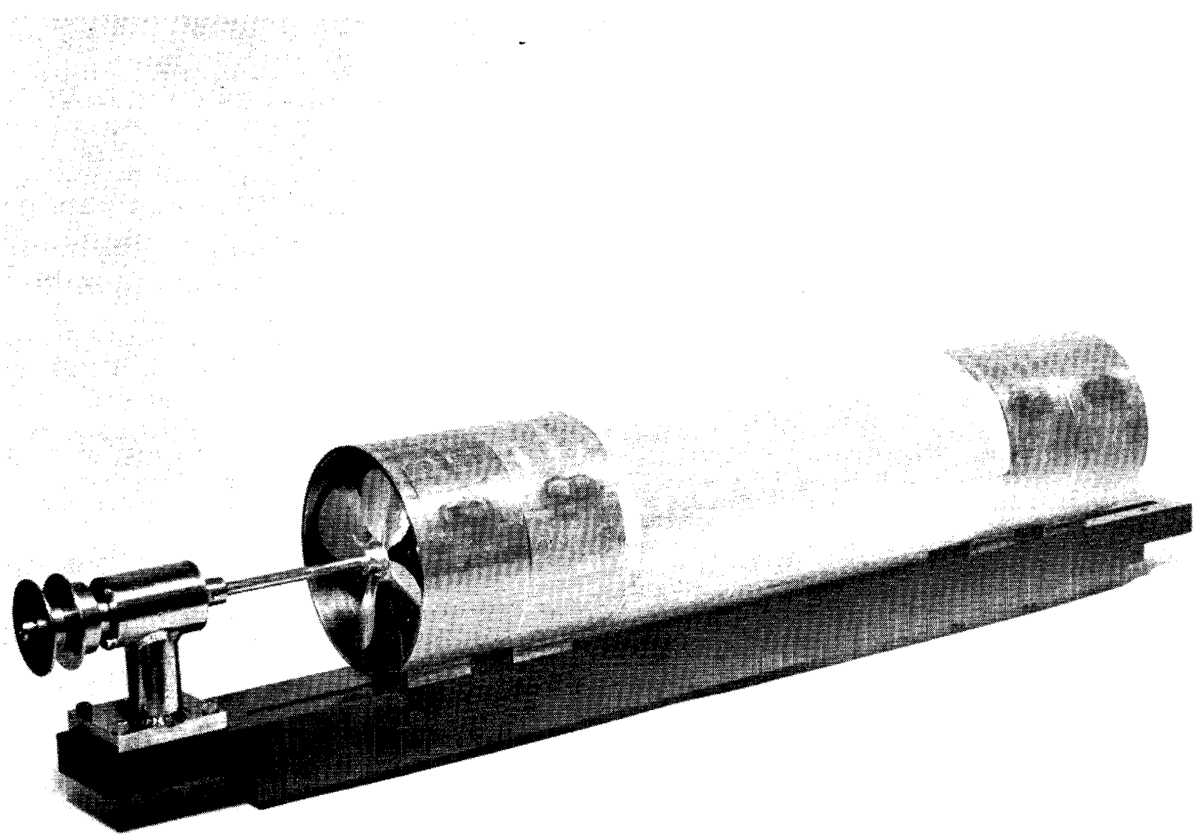


Figure 4. Layout of Air Bearing Test Bed



974-012-1

Figure 5. Air Bearing Test Bed Showing Fan Installation

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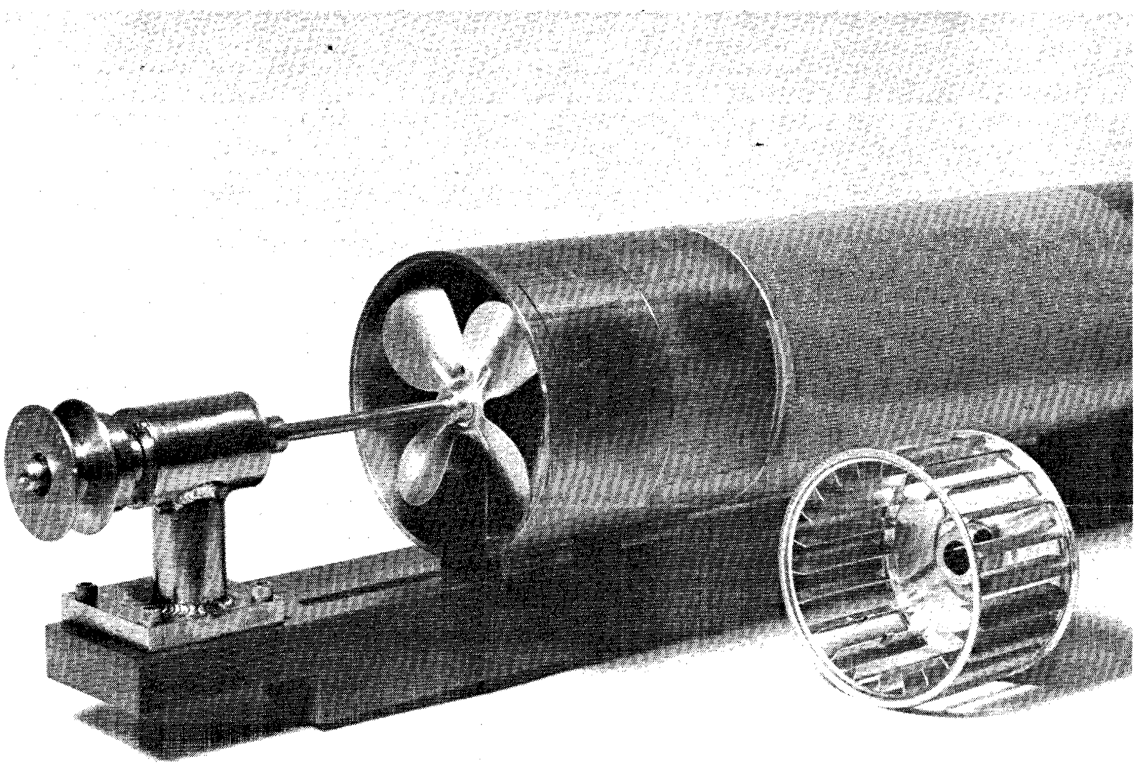

Figure 6. Air Bearing Test Bed Showing Fan Installed and Wheel

974-012-1

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